DESCRIPTION

TITLE

Method and device for controlling the thermal balance in buildings

TECHNICAL FIELD

The present invention relates to a method for controlling the thermal flows in at least one building, according to which method means for controlling the temperature inside the building are controlled on the basis of a plurality of input parameters.

PRIOR ART

Optimizing the thermal flows in a building is something with which residents have always been intensely concerned. The modern means for air conditioning (cooling, heating, setting the humidity of the air) have significantly simplified the control of the thermal flows but great importance is attached to saving energy, in particular in view of the economic and ecological aspects. In particular heating houses (private, commercial and public) entails a large consumption of energy at central European latitudes, and any optimization in this area is potentially highly attractive.

As a result of the large mass/volume of the heated objects they react extremely slowly, and in particular in the case of underfloor heating with a low temperature of the previous cycle switching on/off of the heating has an effect only over hours.

Conventional systems for controlling the heating in a building have temperature sensors on the outside of the building and inside the building.

The heating is correspondingly set as a function of the external temperature, with a target value being predefined and the internal temperature being regulated to this target value. With such methods it is usually not possible to perform short-term and predictive control, for example when there is a sudden increase in the input of heat from the outside (period of sunny weather) or a sudden decrease in the application of heat the control reacts slowly and the temperature inside the building differs greatly from the target value. Correspondingly there is an urgent need to make heater control devices available which permit the process of controlling the means for setting the temperature inside the building to be carried out in an optimum way and as efficiently and predictively as possible.

SUMMARY OF THE INVENTION

The invention is accordingly based on the object of making available a method and a device for controlling the thermal flows in at least one building in which means for controlling the temperature inside the building are controlled on the basis of a plurality of input parameters. The control is to be as predictive and efficient as possible here.

This object is achieved in that the means for controlling the temperature of a specific space under consideration or at least one area of a specific space are actuated by using, as input parameters:
a) at least one target value, in particular the desired temperature of the specific space; b) at least one general parameter which is characteristic of at least one variable inside and/or outside the building which at least indirectly controls the temperature inside the specific space; and c) at least one specific parameter which is characteristic of the specific thermal flow

conditions of the specific space under consideration or the area of the specific space; and the control of the means is calculated in a control unit on the basis of these input parameters.

The core of the invention is to configure the control specifically for each space in an adaptive fashion. For this purpose, a target value is defined for each space, and said value may be different for different spaces. This target value may either be defined in a fixed way by the user, possibly as a function of the time of day and the day of the week etc. (timetable). Or else it is also possible to derive this target value as it were from a history, i.e. the control unit "observes", possibly additionally by means of movement sensors, the effective use of the corresponding space and automatically adapts the thermal flows to the use which is actually expected. If, for example, a space is never used at the weekend and usually also not on a Monday morning, the control unit detects this and after a certain number of repetitions of such regular behavior the control unit reacts automatically by setting the target value to a minimum value which is to be correspondingly defined if typically there is no person in the space, and to another target value if typically it is to be expected that the person will be present. The presence of persons may be determined, as already mentioned, by means of sensors in a way which is space-specific, but it is also possible to derive this, for example, by means of indirect variables such as presence of the person who usually works in the space under consideration, as can be determined from a time monitoring system or by means of interrogations in the local computer network as to whether or not the person under consideration is logged in.

Furthermore, at least one general parameter is used as an input variable, which parameter is representative as it were, of external variable factors which influence

the thermal flows of the space under consideration. Such factors are typically, for example, the temperature outside the building, with this temperature being preferably measured as far as possible at locations which are particularly relevant for the space under consideration.

However, in particular specific parameters are additionally provided as an input variable for the control, with these specific parameters being characteristic of the input of heat into the room under consideration, or the outflow of heat from it. The parameters here are typically variables such as, for example, the window areas of the space under consideration and their insulation state, or such similar variables. The temperature control means are typically at least a heater. Alternatively or additionally it is possible for these means to comprise at least an air conditioning system and/or at least a ventilation system and/or at least a device for controlling the solar radiation (for example sun blinds) into the space.

According to a first particularly preferred embodiment of the present invention, the control unit has access to a database in which historical values of the parameters (b, c) and the target values (a) of the specific space under consideration and/or the specific building under consideration are contained. Correspondingly, the control of the means for controlling the temperature is carried out on the basis of the input parameters taking into account these historic values, wherein the control of the means for controlling the temperature on the basis of the input parameters in an adaptation process while taking into account these historic values is particularly preferred. The process here is, as it were, an intelligent learning process which takes place in the control unit and which takes into account, in an

optimum way, the microclimate which is typical of the specific building and of the specific room. Inter alia, this embodiment has the advantage that such a system does not need particular installation steps which are to be adapted to the specific object since, after a specific learning time period in which the system optimizes itself automatically, the control is set in a specific optimum way. A combination is of course possible if an approximate data record, which is assumed for the specific object, is already stored during installation as a starting value for the history, in order to avoid the transient response behavior of the control which usually occurs during such learning processes being too pronounced.

Typically the at least one general parameter is a parameter, or a selection from the following parameters, measured in particular by means of sensors: temperature on the outside of the building under consideration (temperature sensors on different facades at different heights on the outside of the building); humidity on the outside of the building under consideration (humididity sensors likewise at the different facades); the wind, and the direction of the wind in particular, on the outside of the building under consideration (e.g. wind wheel on the roof); the solar radiation on the outside of the building under consideration (brightness sensors likewise on different facades on the outside or possibly inside the space at locations where owing to the windows solar radiation can be expected). Herein these general parameters are particularly preferably measured at a plurality of locations with different climatic controls such as, for example, at different facades and/or on the roof of the building, possibly at different heights.

It is particularly advantageous if in addition information about the weather forecast, in particular of the region (under certain circumstances a

combination of global weather forecasts, for example for the country, and of local weather forecasts, for example for the region) is used as a general parameter. This data may consist, for example, in precipitation probabilities, probabilities of hours of sunshine etc. made available by a corresponding provider in a defined form as a function of the time of day. In addition it is possible to calculate sunrise and sunset from the data and to use it for the control.

A system such as this can be particularly easily implemented with the contemporary technical means if the general parameters are periodically or continuously transferred to the control unit via a cabled or cableless network, in particular preferably by means of a LAN, wireless LAN, GPRS or the like using standard protocols such as SMTP, ftp, http. It is particularly easy to integrate, for example, the weather forecast into the system by periodically accessing the corresponding provider by the control unit via the WWW in order to achieve the corresponding information, or by the information being actively transmitted to the specific control units by a provider. This may be done by using standard protocols such as, for example, SMTP or HTTP, with the information being transferred in a defined form (e.g. XML/SOAP) so that it can be further processed automatically by the control units.

Another preferred embodiment of the present invention uses not only the parameters measured at the building under consideration but also uses parameters from other buildings which are integrated in a system of the same type. This permits wide ranging adaptation of the control to the microclimate which is valid for the object in question. Thus, general parameters such as those described above can correspondingly also be used as input parameters, said parameters being measured at at least one other building and these other buildings being preferably arranged adjacent or at a distance

which is relevant for the air conditioning system, in particular the microclimate, at the building under consideration. Again, it proves particularly easy and efficient to transfer these input parameters from other buildings via the www, WAN, LAN or similar network to the control unit of the building under consideration or to make it available to said control unit. This may be done, for example, in such a way that each building of corresponding grouping makes its data available to the control units of other buildings in a general database administered by a provider. The control units of other buildings can then correspondingly access the totality of this data and optimize the process of controlling it, which may be attractive in particular in conjunction with the abovementioned learning process using a history if not only the current values but also historic data is included in this database of the building.

In order to ensure feedback between the target value and the value which is actually reached for the temperature in the space under consideration, the value of the temperature in the specific space under consideration and/or the value of the temperature in specific adjacent spaces should also be used as input parameters.

Typically, the at least one specific parameter (c) mentioned at the beginning is one of, or a selection from, the following parameters: window face; insulation state; orientation with respect to the cardinal direction and solar radiation; shadowing by adjacent buildings and/or vegetation - particularly if appropriate season-specifically - or topography; height of building above sea level; coordinates of the building. In this context, these specific parameters (c) can either be determined once and input into the control unit and/or the entire control of at least some of these specific parameters can be determined

automatically by the control unit in a possibly continuous adaptation process taking into account the control of the general parameters and the executed actuation of the means for temperature control on the value which is actually brought about in the specific space. In this respect the sensing of historical data is again a great help.

Further preferred embodiments of the method according to the invention are described in the dependent claims.

Furthermore, the present invention relates to a device for controlling the thermal flows in at least one building using a method such as is described above. In this context, the device comprises at least one control unit with which means for controlling the temperature within the building under consideration are controlled, a plurality of sensors for determining the parameters, preferably also the possibility of accessing a weather forecast, and a communications network or at least coupling to a communications network, in particular in the form of a LAN, WAN, www, via which the parameters are transferred or made available from the sensors to the control unit or via which the weather forecast is transferred to the control unit.

In addition, the present invention relates to a control unit for carrying out a method such as is described above or for use in a device such as is described above. The control unit comprises in this context at least one processor, internal means for storing data and at least one network interface, wherein a database on which the data of the input parameters and the actually achieved target values are continuously recorded is preferably provided in the data storage means, and wherein the control unit is configured in such a way that means for temperature control are actuated on the basis of the instantaneous input parameters taking into account the history contents of

the database in an optimizing and learning fashion. Correspondingly, the present invention also comprises a data processing program for carrying out such a method in such a control unit.

Further preferred embodiments are described in the dependent claims.

EMBODIMENTS OF THE INVENTION

A system in which a control unit which is configured, as it were, as a computer is to be described as an exemplary embodiment for the present invention, regulates heating devices such as, for example, heating elements in their supply either with heating fluid or electric current. The control unit has for this purpose a CPU, i.e. a processor, and the possibility of controlling the corresponding controlling means for the heating elements (continuous-flow control or flow control). These control means can be connected to the control unit by means of cabling which is to be especially provided for that purpose but it is also possible to configure these control means as autonomous units which communicate with a local network (LAN, possibly wireless, GPRS) by means of standard protocols (SMTP, http etc.). The expenditure on installation can be significantly simplified by using a network (possibly wireless or PoE) which is usually already present.

Furthermore, the control unit has a network connection via which other data sources can be accessed using standard protocols such as SMTP or http with standard data formats (XML/SOAP), and via which access is also made possible to the control unit from the outside. This network connection may be implemented, for example, by means of a modem. As a result it is also possible to configure the control unit remotely from the outside, i.e. from any desired computer in the same

house or elsewhere, which may be beneficial, for example, at holiday times (preheating of a house in winter before people arrive). Furthermore, the system has sensors which are arranged on the outside of the building under consideration and which are capable of measuring the external temperature and possibly also the external humidity. The sensors are attached to different locations on the outer skin of the building, in particular there is a separate sensor on each façade which has its own climatic characteristics (exposure to the sun, to the wind, to the rain, etc.). Furthermore, if a different climatic characteristic also occurs at a different level of the building on a façade owing to vegetation or the position on a slope, or if the insulation state at different heights is different, sensors are additionally arranged at different heights on the façade. Furthermore, an air speed indicator is located as a wind sensor (direction and strength) on the roof. It is optionally possible also to provide brightness sensors on the outside in order to determine direct solar radiation.

In addition, at least one further temperature sensor is arranged in each of the spaces to be controlled separately in order to permit control to the target value.

The measured values of the individual sensors are transferred to the control unit via cables or lines which are to be specially provided for that purpose, or else it is possible, and this proves particularly advantageous with respect to the expenditure on installation, to integrate the sensors directly into a network (for example LAN, possibly wireless). For this purpose it is possible to configure the individual sensors directly as small autonomous units which themselves have an actual sensor, small processor, possibly storage facilities and in particular a network connection (possibly wireless or alternatively

generally by means of GPRS) so that for the purpose of installation the sensor simply has to be mounted and a connection is then made to the local network via a corresponding network cable or in a wirefree fashion. This method is particularly simplified if such sensor units are configured in such a way that when they are connected they sign on automatically in the network and correspondingly then make the determined data available without further manual configuration of the control unit which is also connected to the network. The use of a network simplifies the installation considerably since nowadays corresponding networks are usually already available by means of hardware, in particular in commercial buildings, and it is therefore not necessary to lay any further cables to install such a control system. In a completely simplifying way it is also possible to consider a network connection via the power supply since of course a sensor generally also has to be supplied with current. Likewise, only one cable is necessary when using PoE (Power over Ethernet) or with wireless technology. The same of course applies to connecting the control means for the heating elements to the control unit. Such a sensor box, comprising a temperature sensor and/or humidity sensor and/or air pressure sensor and possibly further sensors which are relevant to determining the climate, also comprising a processor, possibly means for local data storage (RAM, ROM, hard disk, SANDISK or the like), a network card (modem also possible) for connection to a cabled or wireless network (alternatively connection is also possible to a general radio network with GPRS) as well as, if appropriate, a housing and an internal power supply (battery or accumulator) or external power supply is novel and inventive per se and independent of the system considered above. In particular if such a sensor box is equipped with a data processing program which establishes automatic integration, which does not require any further configuration, into a network, the installation is particularly simple. Thus, for example

an IP address can be assigned automatically (or it is possible to cause it to be assigned using, for example, DHCP) as well as automatic signing on can be carried out at a server which is provided for that purpose and which can either be the control unit or which can be a data server which subsequently makes the data available to one or more control units (in different buildings if appropriate) or else to weather evaluation centers.

The control unit uses the data which is made available in this way to control the heating elements, specifically in a way which is specific to each space. In order to regulate each space ideally in this respect, the specific parameters which are characteristic of the space and which are typical of the input of heat into the space under consideration or the outflow of heat from it, are additionally determined and used. These include, inter alia, the insulation state, window face of the room etc. In addition, the data of those sensors which are actually relevant to the climatic conditions of the room under consideration are considered. In other words, for example the sensors on the outside of the façade which are located at the same height which are arranged on facades on which the space under consideration actually borders are used. It is possible to continuously adapt which sensors are actually of thermal relevance, to which degree, for the space under consideration, i.e. it is possible to cause the control unit to successively learn such considerations or weightings.

The objective here is the most precise possible prediction PER SPACE as to whether said space

a) is used

b) how the application of heat from the outside will be in the next hours (this being solar radiation etc. which can also be considered as a function of

the time of the year because of the different length of day and/or because of different vegetation)

c) wind chill, to what extent a space is cooled from the outside by windows etc

d) etc.

In order to implement this, the following procedure is adopted: each of the sensors transfers its data with object designation and orientation (cardinal direction) via a communications network (Internet, LAN..) into a central database (the central database can either be arranged in the control unit or separately) - the altitude of the object above sea level, precise coordinates, position (on the slope etc.) are also indicated in said database.

The CONTROL of each room is carried out on the basis of the following data:

a1) predefined temperature, possibly with timed control (program control)

a2) "history" - was the space used yesterday, the day before yesterday etc.? Other regularities which can be used?

b1) Weather forecast for the day (since the control unit has a network connection, corresponding data can be automatically integrated periodically by a provider via the Internet and interpreted for the requirements).

b2) Spatial orientation (specific parameter) and input/cooling factor (general parameter)

b3) trajectory of the sun (when does solar radiation

start to enter the space etc.)

Basically, the control process can be based here exclusively on the actual values of the sensors and on a corresponding extrapolation based on the weather forecast which has been consulted. The extrapolation can also be improved by taking into account the trends observed in the measured values of the individual sensors over the last time periods. Typically the trend over the last minutes to hours is referred to.

Further improvement in the control process can be achieved by taking into account not only the data of the sensors of the building under consideration as input variables for the control process but also by taking into account the corresponding measured values of further buildings. This data can be retrieved here by the control units either directly from other buildings which are similarly equipped or else it is possible for each building in such a grouping to store its data on a central server and for all the control units of the respective buildings to be able to access the data at this server. In this context the other buildings can either be in the direct vicinity of the building under consideration but it is also possible to take into account buildings which are located in the same region or even further away and thus, as it were, to improve further the weather forecast by means of corresponding regional tendencies or draw more detailed conclusions for the building under consideration.

A further way of improving the control process may be achieved, and this seems particularly interesting, in that the control unit is, as it were, capable of learning and successively takes into account the microclimate which is relevant to the respective building. This learning capability can be achieved by storing the collected data from the sensors, target values and the corresponding weather forecasts in a

database as part of a history. It is then possible to have the control unit search in a history database for respective similar scenarios of the microclimate which have already taken place (pattern matching). If a similar situation of this type or an identical situation is found in the database it is possible to look up in what respect the control process which was then implemented there was not optimum and to adopt the control process correspondingly for the anticipated behavior in the near future. Values of sensors are therefore retrieved from the database which contains historical data as data which correspond to a maximum degree from the quantity of all the available sensors (with shifting on the time axis) and as a function of the general weather situation, wind direction, wind speed. This may be carried out in a decentralized fashion in the regulator or centrally.

A specific example will serve as an illustration of this:

There is a west wind with an average speed of 20 km/h and the weather forecast is for "40% cloud and no precipitation". Later in the day a westerly front is to arrive. The regulator looks through the database for the sensors which, given this specific weather situation with a run in time of 2 hours, adds the greatest degree of correspondence to the local weather (in this case presumably buildings in the westerly direction, approximately 40 km away). The data of these sensors are used, in the case described, to start up the heating in good time, said heating being assumed to take approximately 2 hours to take effect, before the weather front will greatly cool the building from the outside. Depending on the orientation of the external wall, a significantly greater degree of heating is carried out on the west side than on the east side of the building since the wind cools the building from the west.

A further example relates to the control of sunshades in sultry summer weather. The specific room is shaded by the sunshade. However, since severe thunderstorms may occur locally, the sunshade is retracted in good time if sensors on other buildings in the surroundings of approximately 1 m "wind distance" indicate swirls of wind.